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April 22, 1996

Barrie A. Caldwell
Procurement Technician
NASA Ames Research Center
Moffett Field, California 94035-1000

Dear Ms. Caldwell,

Please find attached my final report on my NASA Ames Agreement No. NCC 2-838. All other reports mentioned in your memo dated April 5, 1996 are provided by other campus departments.

Please let me know if there is any questions regarding this report or any other items needed from me. I can be reached at (510)643-5636.

Sincerely,

Roger F. Malina
Principal Investigator

cc: D. Korsemeyer
T. Morgan
P. Gates
S. Lilly

FINAL REPORT
Agreement No. NCC 2-838
Technology Experiment Demonstrations on the EUVE Flight Testbed Involving a Collaboration between NASA Ames Research Center and the Center for EUV Astrophysics.

In the fall of 1993, CEA faced the prospect that EUVE might be turned off after its primary mission because of budget cuts. Although cost saving measures were examined and implemented throughout CEA, the project was forced to consider radical, new, low-cost approaches for operating the observatory.

A three part strategy was developed which included: (1) converting operations from around-the-clock monitoring to day-shift only monitoring; (2) attempting to reduce the large NASA institutional costs (e.g., TDRSS) of operating EUVE; and (3) operating EUVE as a mission operations testbed to introduce new technology in a systematic and disciplined manner (Malina 1994). The last strategy recognized the need to prototype new technology for reduced cost operations while increasing the value of the mission to NASA as a technology testbed. A concurrent study for Dr. Guenter Reigler of NASA Headquarters Code SZ headed by Dr. Ron Polidan (GSFC Code 681) recommended a transition to one-shift operations for both spacecraft and payload operations to reduce costs on the project.

In order to cut costs to the required level for an extended mission, the Principal Investigator, Dr. Roger F. Malina, was willing to accept an increased level of risk in a slower response time to problems and the potential loss of some science data. Two key factors in accepting this risk were that the primary objectives of the mission had been accomplished and the inherent safety of the EUVE spacecraft and payload had been demonstrated.

Both the spacecraft and the instrument contained on-board safing mechanisms that had performed remarkably well. The payload safing mechanisms had been activated over a dozen times with no recovery problems. As of the date of this report, both spacecraft and payload continue to perform very well. Two partial failures in the tape recorders and one redundant transmitter failure occurred in 1994, none of which has prevented or restricted science operations.

Over 99% of the science data continues to be returned as originally scheduled. No major failures in any payload component have occurred. The risk associated with one-shift operations was mitigated by the introduction of artificial intelligence (AI) software into the EUVE Science Operations Center (ESOC) to monitor the health of the payload during the unstaffed shifts.

Our strategy was to evaluate the potential of several commercial and government developed systems before making a full commitment to implement one-shift operations. Since we intended to introduce an AI system to replace entire shifts, not augment existing operator functions, the system had to work in a fully automated fashion, integrated with our existing software. Some of the key criteria were compatibility with our existing software environment (UNIX, distributed network), extensibility to add our own functions, and good technical support and documentation. User interface capabilities, while important, were not a strong factor in the selection since the software would act in the absence of people. A more detailed discussion of the criteria and packages evaluated can be found at our world wide web (WWW) internet site, http://www.cea.berkeley.edu.

The product that best met our criteria was a commercial product, RTworks, by Talarian Corporation of Sunnyvale, CA. Dr. Mel Montemerlo from NASA Code X and Dr. Dave Korsmeyer from Ames Research Center (ARC) assisted us in establishing collaborations with the Jet Propulsion Laboratory (JPL) and ARC to utilize their expertise in the development of AI software for mission operations. These centers were instrumental in providing technical and programming assistance, recommending techniques and advising us on effective ways to capture the console operators' knowledge and encode

the knowledge into a rule base. Both ARC and JPL provided copies of AI software packages developed at those institutions for our evaluation.

In January 1994, after identifying a suitable AI package for implementation, an internal precommitment review of the proposed transition to one-shift operations was held at CEA for an invited review panel of scientists, engineers, and GSFC personnel. The review placed the transition to one-shift operations within a long term concept for low-cost EUVE operations that included controlled introduction of new technology, more autonomous ground systems hardware, and automated telemetry monitoring. CEA management presented an implementation schedule, cost analysis, payback timetable, and post-transition operations concept as well as planned support roles from CEA departments, such as the Guest Observer Center, software development, hardware systems, engineering, and outside collaborator support from ARC. Payload scientists presented an analysis of the impact on payload health, safety, and science quality of the observations. Based on the recommendation of the panel, the principal investigator (PI) decided to proceed with the implementation.